

INDOOR AIR QUALITY ASSESSMENT

**Garfield Magnet School
176 Garfield Ave
Revere, MA 02151**



Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

Upon referral from an occupational health physician, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) conducted an indoor air quality assessment at the Garfield Magnet School (GMS), 168 Garfield Avenue, Revere, Massachusetts.

On October 5, 2005, Michael Feeney, Director of CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program, made an initial visit to the building. A subsequent visit was made by CEH staff on March 16, 2006. This report discusses results of both visits. The request was prompted by indoor air quality complaints believed to be associated with water penetration problems in the building.

The school is a four-story brick building built in 1991 located approximately an eighth of a mile from Revere Beach. A rooftop penthouse contains various components of the building's heating, ventilating and air-conditioning (HVAC) system. Among these components is a large chiller that is used to provide air-conditioning. The fourth floor contains general classrooms and the media center. The third and second floors house general classrooms, kitchens, cafeterias and a play area. The first floor consists of general classrooms, gymnasium, auditorium, music room and a pool area with locker rooms. An underground-parking garage is located beneath the building. An elevator shaft connects the parking garage to each floor.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). CEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

This school houses grades pre-kindergarten through eighth grade, consisting of a student population of approximately 1,400 and a staff of approximately 220. The tests were taken under normal operating conditions. Test results appear in Tables 1 and 2.

Discussion

Ventilation

It can be seen from the Tables that the carbon dioxide levels were elevated above 800 parts per million (ppm) in 15 out of 26 areas surveyed on October 5, 2005 and in 32 of 67 areas on March 16, 2006, indicating poor air exchange in these areas of the school. It should be noted that a number of areas that had carbon dioxide levels below 800 ppm were measured in unoccupied or areas with low population, which can greatly reduce carbon dioxide levels.

Two separate ventilation systems exist in the school. Offices and common areas are ventilated by rooftop air handling units (AHUs), which are ducted to ceiling-mounted

air diffusers and wall-mounted exhaust vents. Some areas serviced by the AHUs have higher occupancy or were modified for alternate activities (e.g., physical therapy). Consideration should be given to increasing fresh air supply to these areas. Installation of ceiling and wall fans could also aid in improving comfort and air circulation.

Fresh air in most classrooms is supplied by a unit ventilator (univent) system ([Figure 1](#)). The univents were found off in a number of classrooms. Many of these univents appeared to have been deactivated. Obstructions to airflow, such as books, papers and posters on top of univents, and bookcases, tables and desks in front of univent returns were also seen in a number of classrooms. To function as designed, univents and univent returns must remain free of obstructions. It is important that these units be activated and allowed to operate.

Exhaust ventilation in classrooms is provided by a mechanical exhaust system. The exhaust vents are located on the walls at floor level (Picture 1). This design allows for the vents to be easily blocked by stored materials and occluded by floor dust.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room, while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing reportedly occurred over the summer of 2005.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or

openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, see [Appendix A](#).

Temperature measurements ranged from 75° F to 78° F on October 5, 2005 and 69° F to 78° F on March 16, 2006, which were nearly all within the MDPH recommended comfort range. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants.

Occupants from a number of classrooms expressed thermal discomfort. Many expressed problems with classrooms being too cool; however, in a number of areas, furniture was blocking radiators and as discussed, univents were deactivated. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measurements ranged from 51 to 61 percent on October 5, 2005, which were within or very close to the upper level of the MDPH recommended comfort range. Relative humidity measurements ranged from 10 to 28 percent on March 16, 2006¹, which were below the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A number of classrooms (e.g., room 230) had water damaged ceiling tiles. Several of these ceiling tiles were removed, which revealed rusted pipe hangers. This condition can be a sign of water damage resulting from condensation. When warm, moist air passes over a surface that is colder than the air; water condensation can collect on the cold surface. Over time, water droplets can form, which can then drip from a suspended surface. Contributing to this problem may be moisture sources related to the lack of

insulation of both the plumbing and HVAC system components during hot, humid weather. Where breaks or no insulation exists on chilled water pipes, these areas can be subject to condensation generation, which forms water droplets moistening ceiling tiles. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired. Mold can be an eye and respiratory irritant to sensitive individuals. Consideration should be given to insulating pipes appropriate to prevent future condensation problems. Water-damaged materials should be examined and cleaned/disinfected or replaced to prevent mold growth.

Air infiltration was noted around cracked or broken windows (Picture 2). In several rooms the window seals appeared to be failing (Picture 3). In addition, condensation was observed between window panes of several windows, further indicating that seals were no longer intact (Picture 4). Repairs of window leaks are necessary to prevent water penetration and drafts. Repeated water damage can result in mold colonization of window frames, curtains and items stored on or near windowsills.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed.

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be a respiratory irritant to some individuals. Plants should be properly

¹ The sole exception was the indoor swimming pool, which had a measurement of 80 percent relative

maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM_{2.5}) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM_{2.5}.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

humidity on this date.

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it is present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND on both days of sampling (Tables 1 and 2). Carbon monoxide levels measured in classrooms throughout the school were also ND; however levels ranging from 1 to 7 ppm were measured in hallways near the elevator at the center of the building.

These concentrations appear to be related to the presence of an underground parking garage located beneath the GMS. The parking garage is in the shape of a zigzag ([Figure 2](#)), with the elevator lobby at the east end of the lot (Picture 5). A mechanical exhaust system exists in the west wall of the parking garage. The exhaust system draws outside air from a passive air vent in the south wall of the parking garage. A passive outdoor air vent exists in-between the elevator lobby and the exhaust fan ([Figure 3](#)). In

this configuration, it is likely that air and products of combustion from vehicles pool around the elevator lobby. Since the elevator creates the draw of air resulting from heated air rising up the elevator shaft (called the stack effect) and/or the piston-like action of movement by the elevator car, it is likely that the elevator lobby in the parking garage is depressurized. Depressurization will draw air and pollutants from the parking garage when the lobby door is open, through the space under the door (Picture 6) and/or through open seams that exist in the lobby walls and the cement floor (Picture 7). Products of combustion can be irritating to the eyes, nose and throat and should be properly vented outdoors.

As previously mentioned, the US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. According to the NAAQS, PM₁₀ levels should not exceed 150 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM_{2.5} standard requires outdoor air particulate levels be maintained below $65 \mu\text{g}/\text{m}^3$ over a 24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM₁₀ standard for evaluating air quality, MDPH uses the more protective PM_{2.5} standard for evaluating airborne particulate matter concentrations in the indoor environment.

The following ranges of PM_{2.5} concentrations were measured at GMS on the two days of the assessment:

- 17 to 49 $\mu\text{g}/\text{m}^3$ on October 5, 2005 (outdoor concentration was 29 $\mu\text{g}/\text{m}^3$) (Table 1); and
- 1 to 23 $\mu\text{g}/\text{m}^3$ on March 16, 2006 (outdoor concentration was 5 $\mu\text{g}/\text{m}^3$) (Table 2)

Indoor measurements were below the NAAQS of 65 $\mu\text{g}/\text{m}^3$ on both days of assessment.

Frequently, indoor air levels of particulates (including PM_{2.5}) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors. In the case of the GMS a likely source of indoor particulate is migration from motor vehicles in the underground parking garage into occupied areas of the building via the elevator shaft.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND on both days of the assessment (Tables 1 and 2). Indoor TVOC measurements throughout the building were also ND on both days of the assessment (Tables 1 and 2).

Please note, TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC-containing products. While no measurable TVOC levels were detected in the indoor environment, VOC-containing materials were noted. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

During the October 5, 2005 visit, a strong odor of newspaper ink was noted in the hallway outside of room 413. Within this room were several piles of newspapers stacked near the hallway door (Picture 8). A fan was placed next to the newspapers, which was drawing air from the hallway, over the newspapers. Newspapers are made from paper that is printed using a wet ink process. These inks frequently contain VOCs, which off-gas from the paper over time. These VOCs as well as other chemicals used to manufacture paper can be irritating to the eyes, nose, throat and respiratory system.

Plug-in air fresheners and air/carpet deodorizers were observed in a number of classrooms. Air fresheners contain chemicals that can be irritating to certain sensitive individuals. In addition, air fresheners do not remove materials causing odors, but rather mask odors, which may be present in the area.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 9). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas TVOCs. Tennis balls are made with a natural rubber latex bladder, which

becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1998; NIOSH, 1997).

Reused food containers and poorly stored recyclables can create conditions to attract pests into the building. Under current Massachusetts law (effective November 1, 2001), the principles of integrated pest management (IPM) must be used to remove pests in state buildings (Mass Act, 2000). Pesticide use indoors can introduce chemicals into the indoor environment that can be sources of eye, nose and throat irritation. The reduction/elimination of pathways/food sources that are attracting insects should be the first step taken to prevent or eliminate infestation.

Finally, was the amount of materials stored inside classrooms (Picture 10). In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items, (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up.

Conclusions/Recommendations

In view of the findings at the time of the inspection, the following recommendations are made:

1. Seal all seams/breaches in the parking garage elevator lobby. Install weatherproofing around the elevator lobby door. Install a sweep under the lobby door to render the doorframe as air tight and feasible.
2. Consider installing ceiling mounted fans in the center of the parking lot ([Figure 4](#)) to both enhance the draw of air from the parking garage entrance and direct vehicle exhaust from the elevator lobby.
3. Consider relocating the newspaper fan from room 413.
4. Operate univents while classrooms are occupied. Survey all areas with univents for proper function to ascertain if an adequate air supply exists for each room; an increase of fresh air intake may be necessary.
5. Install/repair insulation around areas of the HVAC system that are subject to chronic moistening due to condensation during the operation of the air conditioning system in hot, humid weather. Once repaired, replace any remaining water-stained or missing ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
6. Repair broken windows and replace missing or damaged window caulking to prevent water penetration and drafts.
7. Ensure all plants are equipped with drip pans. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary.

8. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
9. Consider discontinuing the use of tennis balls on chair legs to prevent latex dust generation. Alternative “glides” can commonly be purchased from office supply stores (see Picture 11 for an example).
10. Consider adopting the US EPA (2000b) document, “Tools for Schools”, to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at:
<http://www.epa.gov/iaq/schools/index.html>.
11. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH’s website:
http://mass.gov/dph/indoor_air.

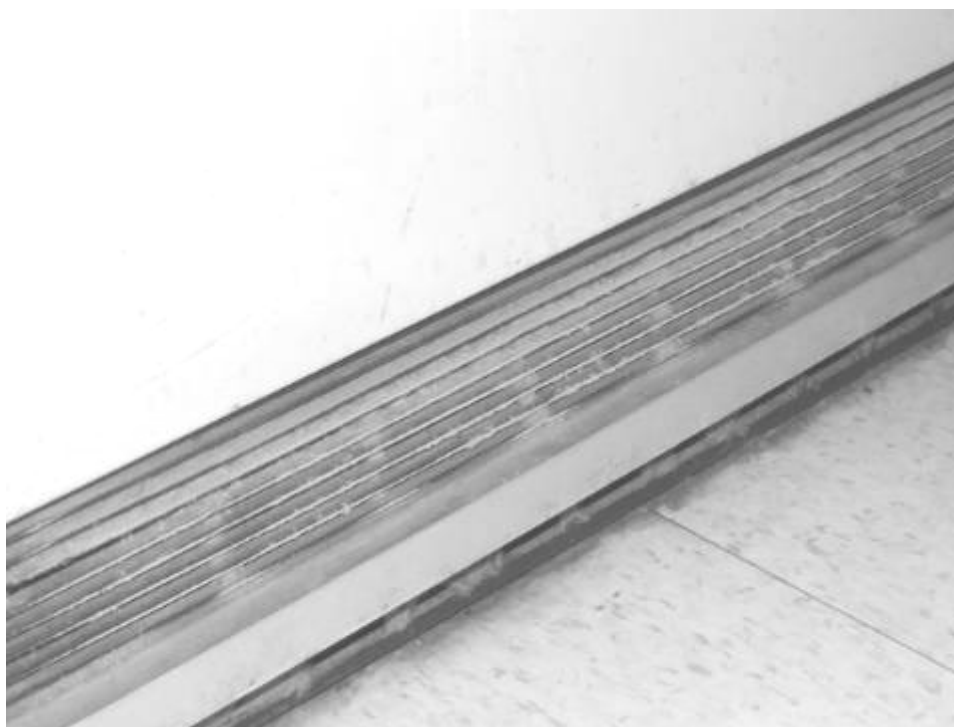
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Picture 1



Exhaust Vents Located at the Base of Hallway Walls within Classrooms

Picture 2



Crack in Window

Picture 3



Failing Rubber Gasket

Picture 4



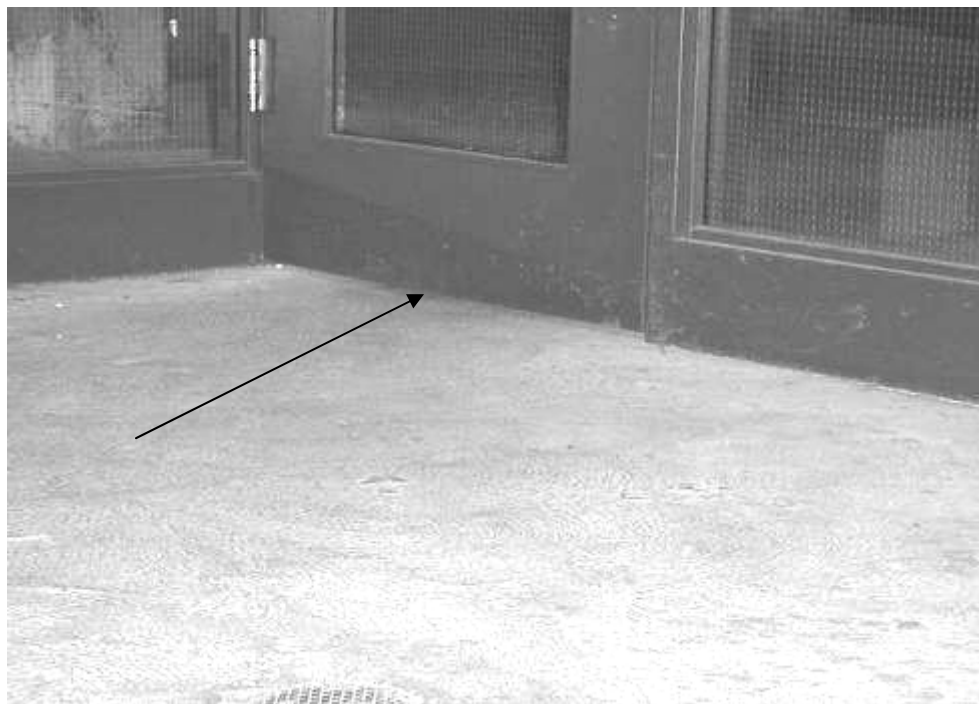
Condensation between Window Panes

Picture 5



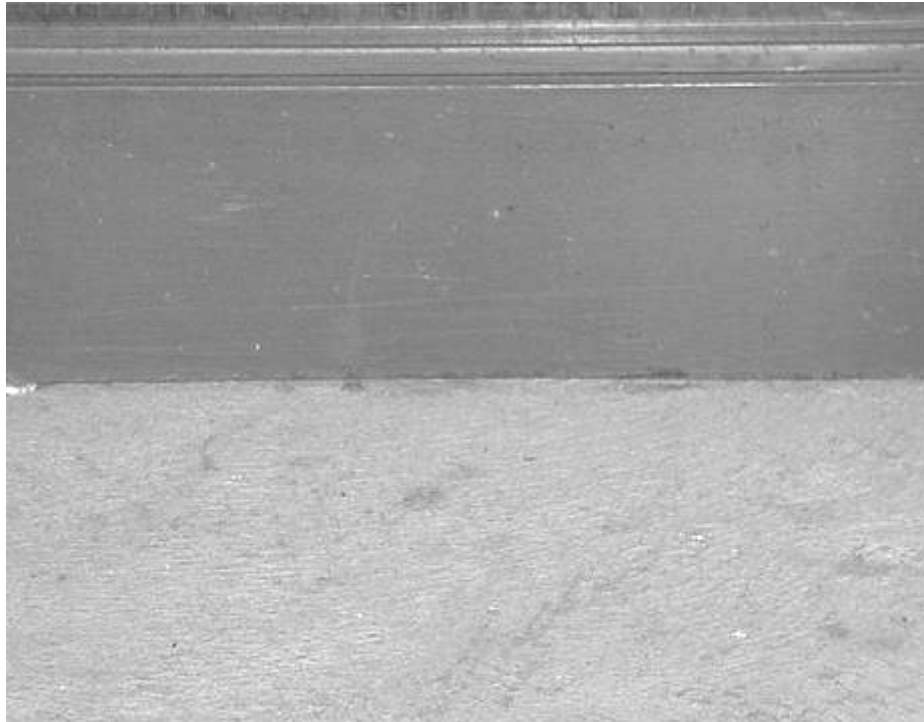
Parking Lot Lobby

Picture 6



Space beneath Elevator Lobby Door in Parking Garage

Picture 7



Seams between the Lobby Glass and Steel Walls and the Cement Floor

Picture 8



Newspapers Stacked Inside Classroom, Note Location and Position of Fan

Picture 9



Tennis Balls Sliced Open and Placed on Chair Legs

Picture 10



Accumulated Materials Stored inside Classrooms

Picture 11



“Glides” for Chair Legs that can be used as an Alternative to Tennis Balls

Location: Garfield Magnet School

Address: Revere, MA

Indoor Air Results

Date: 10/5/2005

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background		61	71	405	ND	ND	29				
436	24	75	54	819	ND	ND	17	Y	Y	Y	DO, DEM
427	24	75	54	802	ND	ND	21	Y	Y	Y	DO, CD
426A	3	75	54	766	ND	ND	28	Y	Y	Y	DO
414	25	76	54	999	ND	ND	22	Y	Y	Y	DO, DEM
413	14	75	52	763	ND	ND	21	Y	Y	Y	DO, PF, News paper odor
415	14	75	54	819	ND	ND	28	Y	Y	Y	AD
423	25	76	58	1186	ND	ND	28	Y	Y	Y	DO
438	24	75	61	1132	ND	ND	20	Y	Y	Y	DO, DEM

ppm = parts per million

µg/m3 = micrograms per cubic meter

AD = air deodorizer

AP = air purifier

aqua. = aquarium

AT = ajar ceiling tile

BD = backdraft

CD = chalk dust

CP = ceiling plaster

CT = ceiling tile

DEM = dry erase materials

design = proximity to door

DO = door open

FC = food container

GW = gypsum wallboard

MT = missing ceiling tile

NC = non-carpeted

ND = non detect

PC = photocopier

PF = personal fan

plug-in = plug-in air freshener

PS = pencil shavings

sci. chem. = science chemicals

TB = tennis balls

terra. = terrarium

UF = upholstered furniture

VL = vent location

WD = water-damaged

WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred

600 - 800 ppm = acceptable

> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F

Relative Humidity: 40 - 60%

Location: Garfield Magnet School

Address: Revere, MA

Indoor Air Results

Date: 10/5/2005

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
433	1	77	53	578	ND	ND	24	Y	Y	Y	DO
434	0	77	53	551	ND	ND	19	Y	Y	Y	DO
437	0	77	54	551	ND	ND	19	Y	Y	Y	DO, DEM
Asst. Principal Office	6	78	52	803	ND	ND	24	Y	Y	Y	DO, PC
319	0	76	51	542	ND	ND	17	Y	Y	Y	
439	18	77	54	962	ND	ND	22	Y	Y	Y	DO, DEM
432	27	78	53	847	ND	ND	19	N	Y off	Y	DO, PF
319	33	76	57	918	ND	ND	28	Y	Y	Y	DO

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 Relative Humidity: 40 - 60%

Location: Garfield Magnet School

Address: Revere, MA

Indoor Air Results

Date: 10/5/2005

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									Supply	Exhaust	
321	28	76	58	970	ND	ND	26	Y	Y	Y	DO, TB
315	22	76	53	523	ND	ND	38	Y	Y	Y	DO, DEM
323	11	76	57	836	ND	ND	31	Y	Y	Y	DO, Cleaners
316	22	75	57	836	ND	ND	27	Y	Y	Y	DO
322	23	76	58	816	ND	ND	49	Y	Y	Y	#WD-CT: 1, DEM
417	25	75	55	767	ND	ND	28	Y	Y	Y	DO
420	6	75	55	767	ND	ND	27	Y	Y	Y	DO
Library	24	77	55	859	ND	ND	43	N	Y	Y	DO
418	0	75	51	515	ND	ND	22	N	Y	Y	

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324	0	76	53	606	ND	ND	29	N	Y	Y	DO, cleaners

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PF = personal fan

plug-in = plug-in air freshener

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Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred

600 - 800 ppm = acceptable

> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F

Relative Humidity: 40 - 60%

Location: Garfield Magnet School

Address: Revere, MA

Indoor Air Results

Date: 3/16/2006

Table 2

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background		52	16	391	ND	ND	5				
334	29	77	19	1458	ND	ND	4	Y	Y	Y	Hallway DO, Fresh air supply blocked with furniture, Exhaust missing louver, DEM, FC Reuse
339A	18	74	15	948	ND	ND	5	Y	Y	Y	DO, CD, DEM
339B	1	75	15	886	ND	ND	4	Y open	Y	Y	DEM, WD-sink counter, Fresh air supply blocked with furniture
332	12	75	18	1055	ND	ND	3	Y	Y	Y	2 WD-CT, 1 MT, DEM, PF
331	18	75	15	871	ND	ND	4	Y	Y	Y	CD, DEM, Materials hanging from ceiling system
333	27	74	16	916	ND	ND	4	Y	Y	Y	CD, 1 MT

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									Supply	Exhaust	
330	0	72	12	665	ND	ND	3	Y	Y	Y	DEM, PF, Furniture blocking radiator, Materials hanging from ceiling system
328	0	72	14	705	ND	ND	3	N	Y	Y	Cleaners
329	2	72	15	676	ND	ND	4	Y	Y	Y	DO, DEM
326 teacher's lounge	1	71	14	995	ND	ND	5	Y	Y	Y	DO, Food storage
327	3	72	14	724	ND	ND	3	Y	Y	Y	DO, 1 MT, CD, Aquarium, Plants, Materials hanging from ceiling system
Computer room	1	69	11	573	ND	ND	3	Y	Y	Y	Fresh air supply weak, Window open, DEM, 32 computers
312	6	72	15	870	ND	ND	3	Y	Y	Y	Fragrance
315	18	73	18	955	ND	ND	4	Y	Y	Y	Exhaust vent off, WD-GW, WD-sink counter, CD, DEM

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									Supply	Exhaust	
313	1	72	13	754	ND	ND	3	Y	Y	Y	DO, WD-GW, WD- sink counter, CD, UF, Materials hanging from ceiling system
324	23	72	14	864	ND	ND	5	Y	Y	Y	Damaged window gasket, Broken window, PF, UF, Exhaust vent off
314	22	72	15	946	ND	ND	3	Y	Y	Y	Exhaust vent off, DO, CD, Plants
322	28	71	25	892	ND	ND	3	Y	Y	Y	Fresh air supply blocked with furniture, CD, TB
327	0	73	12	695	ND	ND	7	Y	Y	Y	WD-GW, WD-sink counter, DEM
320	0	73	18	922	ND	ND	7	Y	Y	Y	Fresh air supply off, Heat complaints, DO, CD
321	23	72	13	775	ND	ND	2	Y	Y	Y	DO, CD, TB
319	0	73	18	890	ND	ND	1	Y	Y	Y	Fresh air supply blocked with furniture, DO, 3 MT, DEM, UF

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									Supply	Exhaust	
318	21	74	18	906	ND	ND	2	Y	Y	Y	Fresh air supply blocked with furniture, DO, CD, DEM
220	7	77	15	1164	ND	ND	3	Y	Y	Y	DO, CD, DEM, Fresh air supply blocked with furniture and boxes
218	23	75	15	1164	ND	ND	5	Y	Y	Y	Plants, Cleaners, CD
216	21	75	15	862	ND	ND	4	Y	Y	Y	WD-GW, WD-sink counter, CD, DEM, Materials hanging from ceiling system, Exhaust vent blocked with furniture
217	19	75	17	1166	ND	ND	5	y	y	y	WD- GW, DEM
222	22	73	12	749	ND	ND	4	Y	Y	Y	DO, CD, Condensation on window
221	16	75	11	721	ND	ND	4	Y	Y	Y	WD-GW, WD-sink counter, CD, DO, CD

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									Supply	Exhaust	
215	29	74	15	705	ND	ND	5	Y	Y	Y	WD-GW, WD-sink counter, CD, DEM, TB, Fresh air supply blocked with furniture
223	21	76	10	616	ND	ND	4	y	y	Y	WD-GW, WD- sink counter, DO, Window condensation
224	16	72	13	720	ND	ND	4	Y	Y	Y	DO, DEM, Plants, Materials hanging from ceiling system, Exhaust vent blocked with furniture
214	19	75	13	755	ND	ND	3	Y	Y	Y	WD-GW, WD-sink counter, DEM, TB
213	19	74	15	880	ND	ND	4	Y	Y	Y	DEM, TB, Window open
225	15	73	11	726	ND	ND	4	Y	Y	Y	WD-GW, WD-sink counter, Plants, Clutter, Fresh air supply blocked with furniture
226A	4	72	11	599	ND	ND	4	Y	Y	Y	FC re-use, Damaged window caulking

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									Supply	Exhaust	
212	21	77	17	1073	ND	ND	2	Y	Y	Y	TB, CD, Plastic odor, Materials hanging from ceiling system, Fresh air supply blocked with furniture, Exhaust vent blocked with furniture
228 computers	2	75	11	736	ND	ND	4	Y	Y	Y	DO, 27 computers
226B	0	75	11	660	ND	ND	8	Y	Y	Y	DO
229	1	76	12	721	ND	ND	3	Y	Y	Y	DO, CD, PF
Cafeteria 2 nd floor	120+	77	15	813	ND	ND	6	Y	Y	Y	DO, Window open
231	0	75	13	923	ND	ND	4	N	Y	Y	DO, CD, PF
230	1	77	11	651	ND	ND	3	N	Y	Y	DO, CD, .PF, Fresh air supply off
335	0	75	12	648	ND	ND	5	Y	Y	Y	2 MT, TB, Broken window

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									Supply	Exhaust	
Cafeteria 3 rd floor	190+	77	16	1195	ND	ND	7	Y	Y	Y	DO, Window open
337	1	74	13	850	ND	ND	4	Y	Y	Y	CD, PS, Fresh air supply blocked with furniture
336	21	75	16	896	ND	ND	6	Y	Y	Y	Cleaners, Water damage sink counter, Fresh air supply blocked with furniture, Fresh air supply off
338	29	78	28	1058	ND	ND	23	Y	Y	Y	WD-sink counter, DO, DEM, CD, Fresh air supply blocked with furniture, Fresh air supply off
Music	23	75	14	680	ND	ND	4	Y	Y	Y	DO, Perfume odor, Window open
Auditorium	10	72	13	571	ND	ND	4	N	Y	Y	
Pool	26	76	80	886	ND	ND	2	N	Y	Y	

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									Supply	Exhaust	
Gym	80+	75	27	616	ND	ND	7	Y	Y	Y	2 MT
121	8	72	13	662	ND	ND	7	Y	Y	Y	CD, Cleaners
120	4	72	13	664	ND	ND	3	Y	Y	Y	DEM
116	14	74	18	794	ND	ND	4	Y	Y	Y	WD-sink counter, DO, TB, Plants, Exhaust vent off
122	10	72	11	698	ND	ND	5	Y	Y	Y	WD-sink counter, CD, Window condensation, Fresh air supply blocked with items, Exhaust vent off
115	10	75	20	671	ND	ND	4	Y	Y	Y	DO, WD-sink counter, Materials hanging from ceiling system, Exhaust vent off
123	0	72	13	697	ND	ND	5	Y	Y	Y	WD-sink counter, Damaged window caulking, CD, PC, TB, UF, Materials hanging from ceiling system, Laminator, Cracked wall, Exhaust vent off

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									Supply	Exhaust	
114	12	75	12	829	ND	ND	5	Y	Y	Y	WD-sink counter, TB, Materials hanging from ceiling system, UF, aquarium, Cleaners, Plants, Fresh air supply blocked with furniture, plants, Exhaust vent off
124	14	73	12	641	ND	ND	4	Y	Y	Y	Materials hanging from ceiling system, Window condensation, Fresh air supply blocked with items, Exhaust off
113	13	72	15	715	ND	ND	4	Y	Y	Y	WD-ceiling, WD-GW, AD, DEM, Window open
125	3	72	15	826	ND	ND	5	Y	Y	Y	DO, DEM, PC
126A	2	74	11	605	ND	ND	4	N	Y	Y	1 WD-CT, 1 MT, DEM, PF, Cleaners
113A	0	75	11	593	ND	ND	5	N	Y	N	WD-ceiling, WD-GW, Plug-in air freshener

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									Supply	Exhaust	
112	16	75	17	800	ND	ND	4	Y	Y	Y	DO, WD-ceiling, WD-GW, WD-sink counter, Damaged window caulking, Broken window, Materials hanging from ceiling system
126 computer room	19	75	13	772	ND	ND	4	N	Y	Y	DEM, 26 computers
219	25	74	16	942	ND	ND	5	Y	Y	Y	WD-ceiling, WD-GW, 4 MT, Materials hanging from ceiling system, CD, DEM, Window open

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Figure 2
General Configuration of Underground Parking Garage

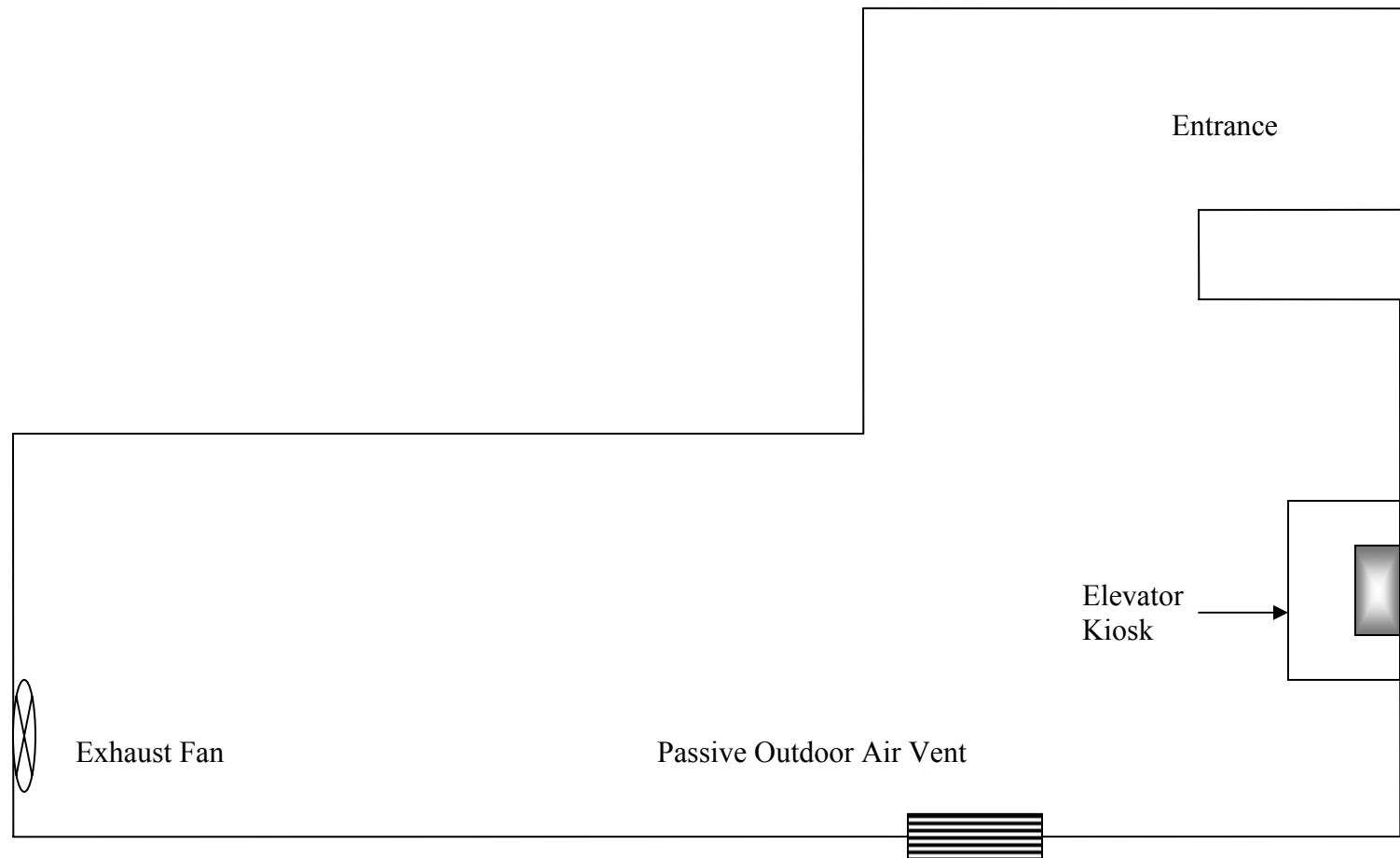
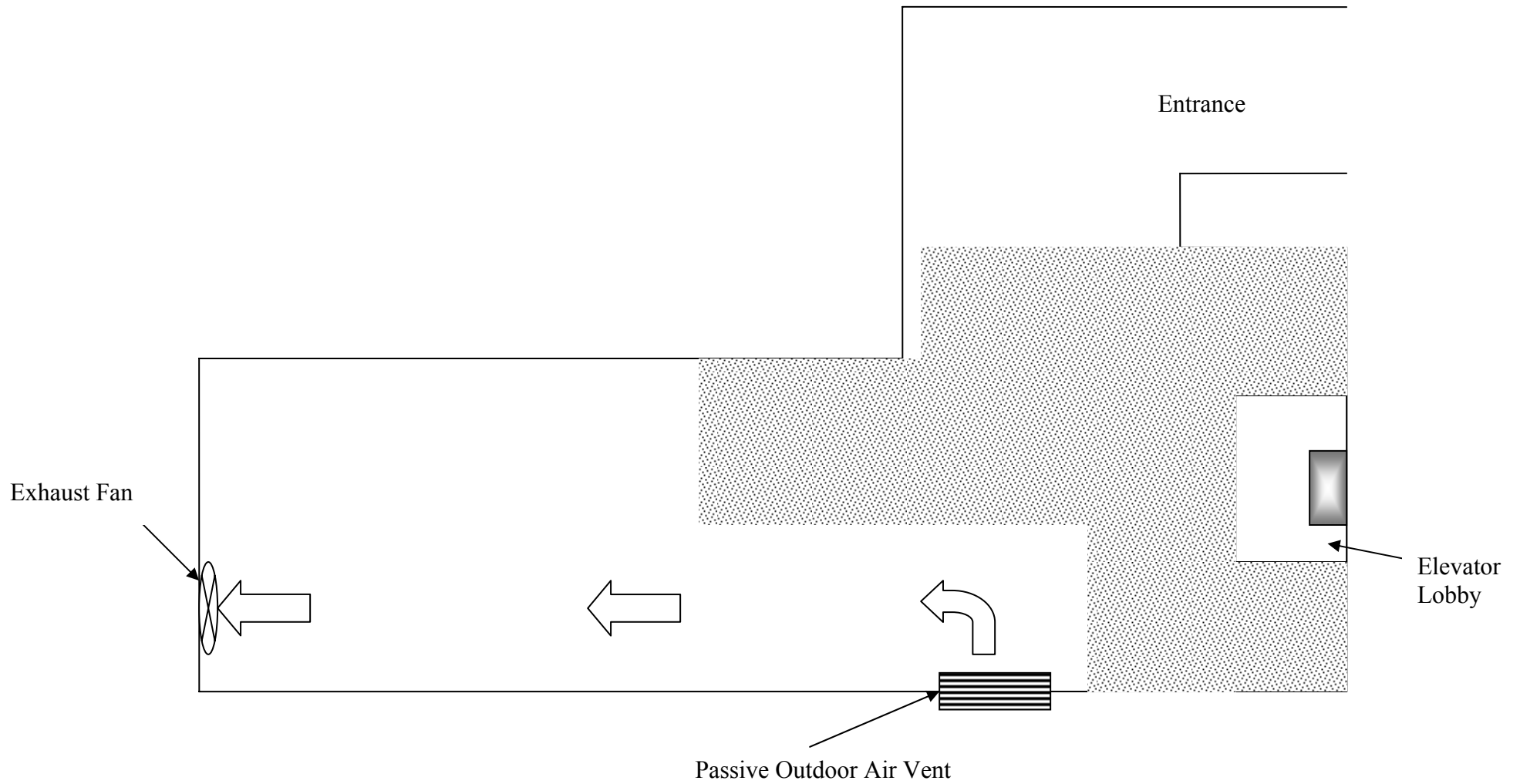


Figure 3
General Location of Pooling Air around Elevator Lobby



← Air Movement

▒ Likely neutral air pressure locations

Figure 4
General Area Where Fan to Increase Draw of Vehicle Exhaust May Be Placed

